

Week 4: Bandwidth

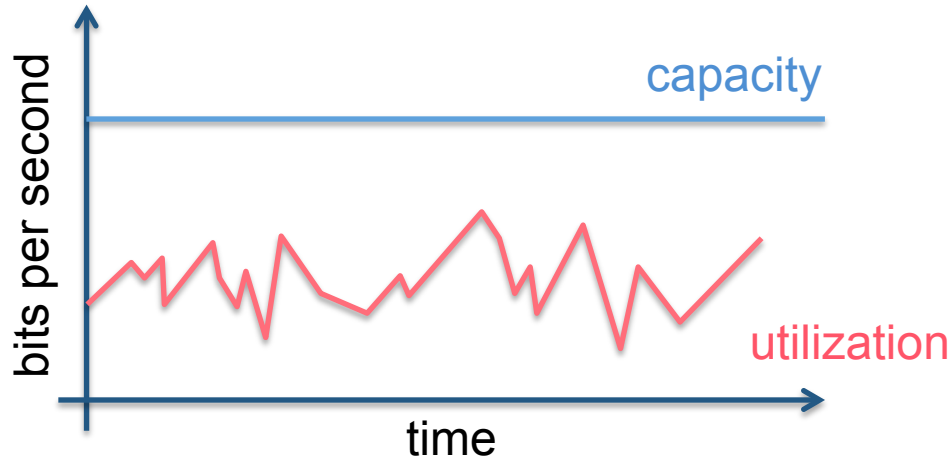
1. Introduction
- 2. Definitions of bandwidth metrics**
 - A. The basics**
 - B. Limitations
3. End-to-end measurement approaches
4. Flooding
5. Advanced probing
6. Conclusion

Link capacity

- Link capacity ($C(\Delta t)$) = IP-layer capacity
 - Maximum IP-layer rate of maximum-sized packets
 - IP-layer capacity depends on size of packet relative to layer-2 overhead

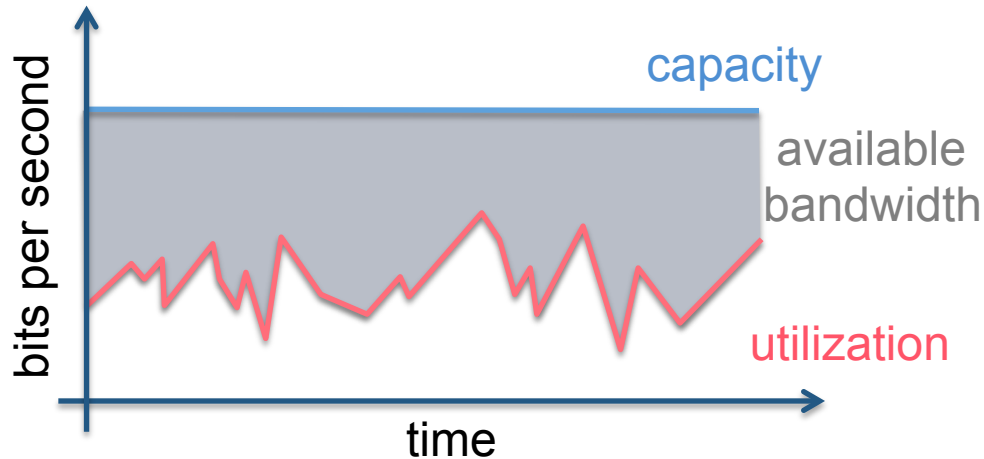
Link utilization

- Link utilization ($u(\Delta t)$)
 - $u(\Delta t)$ = Average bits transmitted on the link during Δt
 - Percent utilization = % link capacity that is utilized



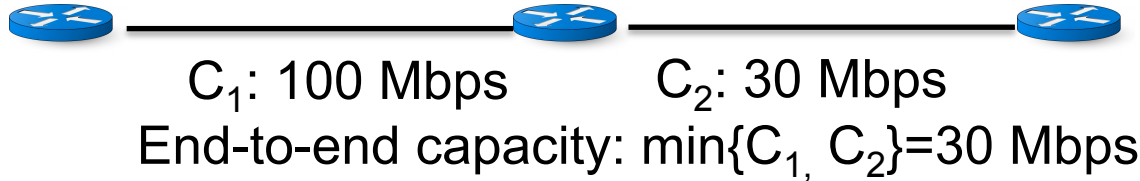
Link available bandwidth

- Available bandwidth ($A(\Delta t)$)
 - Maximum unused bandwidth
 - $A(\Delta t) = C(\Delta t) - u(\Delta t)$



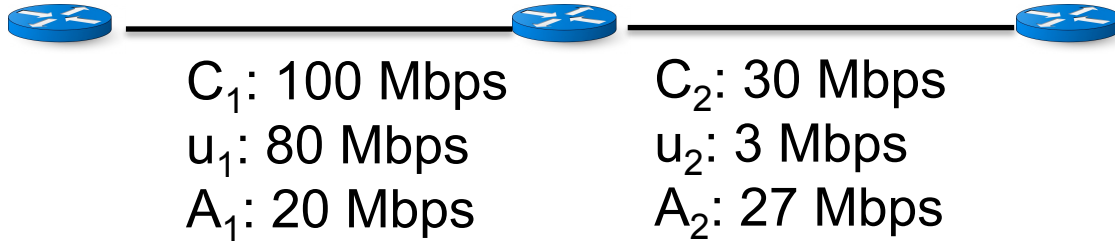
End-to-end capacity

- End-to-end capacity
 - Maximum possible capacity of the path



End-to-end available bandwidth

- End-to-end available bandwidth
 - Minimum available bandwidth of all hops



End-to-end available bandwidth: $\min\{A_1, A_2\}=20$ Mbps

Bulk transfer capacity

- Bulk transfer capacity
 - Throughput of single TCP connection during bulk transfer

Picture credits

- Slides 5 & 6: **Router clip art** by OCAL, www.clker.com (public domain)